COSEWIC
Assessment and Status Report

on the

Northern Goshawk
Accipiter gentilis laingi

in Canada

THREATENED
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC
Assessment Summary

Assessment Summary – May 2013

Common name
Northern Goshawk

Scientific name
Accipiter gentilis laingi

Status
Threatened

Reason for designation
Over half of the global range of this subspecies occurs in coastal British Columbia, where it favours mature coniferous forest. This non-migratory bird needs a relatively large home range that contains a good food supply. Despite some recent habitat protection efforts, continuing habitat loss is predicted, in part because of anticipated short rotation times in forest harvest. On Haida Gwaii, populations are very low and face an added risk from declines of prey species due to forest understory losses associated with high levels of browsing from an introduced population of deer.

Occurrence
British Columbia

Status history
Designated Special Concern in April 1995. Status re-examined and designated Threatened in November 2000 and May 2013.

COSEWIC
Executive Summary

Northern Goshawk
Accipiter gentilis laingi

Wildlife Species Description and Significance

The Northern Goshawk *laingi* subspecies (*Accipiter gentilis laingi*) is a raven-sized, robust forest-dwelling raptor. Adults are brown-grey to slate-grey on the back, while underparts are pale-grey with fine horizontal grey bars and darker vertical streaking. The head has a distinctive whitish line above the eye and a dark-grey to black cap. Immature birds are an overall mottled brown. This hawk is a top-level avian predator in mature and old coastal rainforests and is considered an indicator species of these habitats, as well as an indicator of forest health and biodiversity.

Distribution

The range boundaries for this particular subspecies are inexact. It occurs in Alaska (south of Glacier Bay National Park through the Alaskan mainland and southeast islands of the Alexander Archipelago); British Columbia (Haida Gwaii, Vancouver Island, the coastal islands, and the coastal mainland west of the Coast Mountains); and likely western Washington.

Habitat

The Northern Goshawk *laingi* subspecies selects breeding habitat based on forest stand structure rather than on stand age or tree species composition. Although it may breed in younger, more even-aged stands, it tends to nest in areas dominated by mature or old-growth trees, or in stands with similar structural characteristics (e.g., relatively closed, multi-layered canopies with some large live trees and snags). It prefers to breed in larger, intact patches of forest rather than small isolated stands.

Biology

The Northern Goshawk *laingi* subspecies is a short-distance, non-migratory wanderer. Males primarily remain on or near their nest territories year-round, while females tend to make short-distance movements to mostly lower elevations in winter. Most individual birds initiate breeding at ≥3 years of age. Generation time is thought to be 5 years. Average clutch size is between 2-4 eggs. Only one clutch is produced per season. Mean nest productivity ranges from 1.6 to 2.0 fledglings, depending on region.

This hawk is a generalist predator of medium-sized birds and mammals. Diet varies by region and season, but consists mainly of Red Squirrels, thrushes, jays, grouse and woodpeckers.

Population Sizes and Trends

Based largely on a habitat supply model, just over 1000 mature individuals are estimated to occur in Canada. This amounts to about half the global population. Population trend data do not exist and historical population levels are largely unknown. However, based on habitat loss and degradation, it is assumed that populations have declined from historical levels, especially on Haida Gwaii. Continued population declines are projected to occur, based on projected reductions in the amount of mature forest.

Threats and Limiting Factors

The main threat is commercial forest harvesting that impacts nest sites, prey abundance, and prey availability by reducing and fragmenting nesting and foraging habitat. Other threats and limiting factors are considered minor, except for the Haida Gwaii population of goshawks, which is indirectly impacted by a population of introduced deer, which is thought to reduce the abundance of prey through over-browsing of ground cover vegetation. The small population of goshawks that occurs on Haida Gwaii also has the highest risk of genetic isolation compared to other populations of the subspecies.

Protection, Status, and Ranks

The Northern Goshawk *laingi* subspecies is listed as Threatened under Canada's *Species at Risk Act*. Several provincial acts and land use plans provide some degree of direct and indirect legal protection. A Provincial Recovery Strategy was completed in 2008, and a management plan was completed in 2013. In British Columbia, the subspecies is provincially Red-listed (a candidate for Endangered or Threatened status in British Columbia) and a Priority 1 species (the highest conservation priority) under the provincial Conservation Framework.

Habitat Protection and Ownership

In Canada, a recent estimate of the amount of potential habitat that has some degree of protection is a maximum of about 4.7 million ha, or 35% of the bird's total potential habitat. In southeast Alaska, about 1.4 million ha (55% of the productive forest that is potential habitat for the subspecies) also has some form of protection.

TECHNICAL SUMMARY

Accipiter gentilis laingi
Northern Goshawk *laingi* subspecies Autour des palombes de la sous-espèce *laingi*
Range of occurrence in Canada: British Columbia

Demographic Information

Generation time. See **Life Cycle and Reproduction**	5 yrs
Is there an inferred continuing decline in number of mature individuals? Evidence for ongoing decline is inferred based on continued habitat loss and degradation; see **Habitat Trends** and **Fluctuations and Trends.**	Yes
Estimated percent of continuing decline in total number of mature individuals within 10 years or 2 generations.	Unknown
Estimated percent reduction in total number of mature individuals over the last 15 years or 3 generations.	Unknown, but likely <10%
Suspected percent reduction in total number of mature individuals over the next 15 years or 3 generations.	Unknown, but likely <10%
Suspected percent reduction in total number of mature individuals over any 15 years or 3 generations period, over a time period including both the past and the future.	Unknown, but likely <10%
Are the causes of the decline clearly reversible and understood and ceased? See **Habitat Loss and Fragmentation**	No
Are there extreme fluctuations in number of mature individuals? See **Fluctuations and Trends**	No

Extent and Occupancy Information

Estimated extent of occurrence (EO) See **Canadian Range**; this value is likely an underestimate as it is a calculation of a minimum convex polygon that contains only known nest territories.	190,028 km²
Index of area of occupancy (IAO) Based on applying a 2 x 2 km cell grid around each of the 370-415 nests (see **Abundance**) yields an IAO of 1480-1660 km^2, but this is an underestimate; see **Canadian Range.**	>2000 km²
Is the total population severely fragmented?	No
Number of locations.	Unknown but >10
Is there an inferred continuing decline in extent of occurrence?	No
Is there an inferred continuing decline in index of area of occupancy? IAO is heavily influenced by population trend; see **Habitat Trends** and **Fluctuations and Trends**	Yes
Is there an inferred continuing decline in number of populations?	No
Is there an inferred continuing decline in number of locations? Based on losses of nesting habitat within individual forest cut blocks.	Yes
Is there an observed continuing decline in area and quality of habitat? See **Habitat Trends** and **Fluctuations and Trends.**	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Haida Gwaii	48-57
North Coast	365-383
South Coast	301-343
Vancouver Island	390-454
Total Canada (Based on a 40% foraging habitat supply model; assumes that an estimated 33% of the total population consists of unmated adults; ignores periodic reductions in population size that likely stem from harsh winters and/or poor food supplies; see **Abundance**).	**1104-1237**

Quantitative Analysis

Steventon (2012) reported that at least 800 mature breeding individuals would be required to meet 90% persistence over 100 years, but this result was based on a simple model that assumed that British Columbia contains a closed population, ignoring potential for immigration from the U.S. The calculated risk of extirpation, therefore, is overly conservative (see **Fluctuations and Trends**).

Threats (actual or imminent, to populations or habitats)

Forest harvesting and other commercial-scale activities that remove trees can impact nest sites and prey abundance at both the stand and landscape levels, by reducing and fragmenting nesting and foraging habitat.
The Haida Gwaii subpopulation has a high risk of genetic isolation and is also indirectly impacted by introduced species, particularly deer, which likely reduces the availability of prey because of over-browsing of ground cover vegetation.

Rescue Effect (immigration from outside Canada)

Status of outside population? Listed federally by the U.S. Forest Service as a Sensitive Species (1994) in Alaska. Forest habitat supporting the population in southeast Alaska is currently projected to decline by about 11% by the year 2100.	
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely? Projected continued loss of habitat in Alaska suggests that rescue is unlikely.	No

Status History

COSEWIC Status History: Designated Special Concern in April 1995. Status re-examined and designated Threatened in November 2000 and May 2013.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Threatened	C2a(ii)
Reasons for designation: Over half of the global range of this subspecies occurs in coastal British Columbia, where it favours mature coniferous forest. This non-migratory bird needs a relatively large home range that contains a good food supply. Despite some recent habitat protection efforts, continuing habitat loss is predicted, in part because of anticipated short rotation times in forest harvest. On Haida Gwaii, populations are very low and face an added risk from declines of prey species due to forest understory losses associated with high levels of browsing from an introduced population of deer.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion; no reliable trend estimate is available.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criterion. While the index of area of occupancy is <2000 km^2 and a population decline can be inferred based on habitat loss and degradation, the population is not severely fragmented, there are >10 locations, and there are no extreme fluctuations in any biological attribute.
Criterion C (Small and Declining Number of Mature Individuals): Meets Threatened under the C2a(ii) criterion, because there are <10,000 mature individuals, there is an inferred continuing population decline, and one subpopulation has 100% of all mature individuals. Available genetics and other information suggest that there is sufficient genetic interchange to consider the BC population as a singular unit, rather than as a series of separate subpopulations.
Criterion D (Very Small or Restricted Total Population): Close to meeting Threatened under the D1 criterion, as the total estimated population size (1104 to 1237 adults) is close to the threshold of <1000 mature individuals.
Criterion E (Quantitative Analysis): While a preliminary Population Viability Analysis (PVA) suggested that the Canadian population could face a 10% risk of "quasi-extinction" within 100 years, the model did not account for any immigration from the U.S. and is therefore overly pessimistic.

PREFACE

This report deals only with the *A. g. laingi* subspecies of the Northern Goshawk. The other subspecies in Canada – the much more common and widespread *A. g. atricapillus* – was assessed as Not at Risk in 1995. Its status has not been reassessed since then, because all indications are that the *A. g. atricapillus* population is faring well across its Canadian range.

Since the previous COSEWIC status report for *A. g. laingi* was completed in 2000, there has been significant inventory, research and monitoring done in British Columbia, particularly on Vancouver Island and Haida Gwaii. Inventory work and the reporting of nests by forestry companies have increased the number of known territories in Canada, and provided better information on inter-territorial distances. Radio-telemetry work on Vancouver Island has provided some insight into home range size and dispersal patterns and distances. Nest territory monitoring has provided annual occupancy rates and estimated productivity levels. Specific requirements for foraging habitat and foraging range size are still lacking and are a large knowledge gap.

Additionally, since the last status report, estimates have been made for the amount of habitat loss that has occurred since historical times and for losses projected forward. Nesting and foraging habitat models have been completed and field verified for coastal British Columbia. These habitat models have been used to generate more accurate population estimates and are helping to identify Critical Habitat under Canada's *Species at Risk Act*. In British Columbia, the Identified Wildlife Management Strategy has established 28 Wildlife Habitat Areas around known nesting areas. Other conservation measures have also been introduced by the province and the forest industry.

Finally, genetic analyses completed since the last status report suggest that previous notions on the range of the subspecies may require further refinement with the completion of additional genetic analyses. Analyses found current and historical gene flow among all populations of *A. g. laingi* and in many cases with *A. g. atricapillus*. It appears that Northern Goshawk *laingi* subspecies population assemblages interact through a metapopulation framework; populations are not panmictic. Vancouver Island birds demonstrate genetic affinities with *A. g. atricapillus* and may represent an area of intergradation consistent with a contact zone between the two subspecies. Populations of the *laingi* subspecies on Haida Gwaii, the Alexander Archipelago, and the former Kispiox Forest District on the coastal mainland of British Columbia appear to be the most genetically aligned with one another.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2013)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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2013

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Accipiter gentilis laingi* (Linnaeus)

English Names: Northern Goshawk *laingi* subspecies (formerly known as the "Queen Charlotte" Northern Goshawk)

French Name: Autour des palombes de la sous-espèce *laingi*

Classification: Class – Aves
Order – Accipitriformes
Family – Accipitridae
Genus – *Accipiter*
Species – *gentilis*
Subspecies – *laingi*

Accipiter gentilis laingi is one of three subspecies of Northern Goshawk that are recognized in North America (Taverner 1940; AOU 1983). In Canada, only *A. g. atricapillus* and *A. g. laingi* occur. The subspecies designation of *laingi* was originally based on morphological characteristics – size and colour (USFWS 2007b). The taxonomy has not been revisited to take into account recent results of genetic studies (Sonsthagen *et al.* 2004, 2012; Bayard de Volo 2008; Talbot *et al.* 2005, 2011).

Recent mitochondrial DNA (mtDNA) analyses on suspected Northern Goshawk *laingi* subspecies populations have provided some insight into the complexity of clearly defining a subspecies (Talbot *et al.* 2005, 2011). Analyses of samples taken from southeast Alaska, Haida Gwaii, Vancouver Island, and coastal British Columbia found unclear genetic distinction at the subspecies level across the currently accepted range of the Northern Goshawk *laingi* subspecies (Talbot *et al.* 2011; S. Talbot pers. comm. 2011). Birds on Vancouver Island have genetic affinities with both *A. g. atricapillus* and *A. g. laingi,* but were closest to the former. These birds also display genetic signatures consistent with a contact zone between the two subspecies. Populations in the interior portions of British Columbia's north coast (i.e., the former Kispiox Forest District, currently the central portion of the Kalum Forest District) were the most closely genetically aligned with both Haida Gwaii and southeast Alaska populations. Small sample sizes along coastal British Columbia (between Vancouver and the former Kispiox Forest District) did not provide sufficient resolution for determining genetic relationships.

Morphological Description

A. g. laingi was first described from a type-specimen collected on Haida Gwaii by Taverner (1940), based on its darker plumage than that of *A. g. atricapillus*. Later descriptions of the subspecies indicated that the *laingi* subspecies was also typically smaller in size (Beebe 1974; Johnson 1989).

The Northern Goshawk *laingi* subspecies is a medium-sized, robust forest-dwelling raptor that is about the size of a raven (length: 56–61 cm; wingspan: 98-115 cm; Squires and Reynolds 1997). As with most raptor species, females tend to be larger than males (Johnsgard 1990: Iverson *et al.* 1996; McClaren 2003). Otherwise, both sexes are similar in appearance.

Adults are brown-grey to slate-grey on the back, while underparts are pale-grey with fine horizontal grey stripes and darker vertical streaking (Johnsgard 1990; Kenward 2006). The head has a distinctive whitish line above the eye and a dark-grey to black cap. The eye is orangey-brown to red in colour with red typically characteristic of an older bird. The tail is grey with five dark alternating broad bands with a thin whitish terminal band at the tip. Long undertail coverts are white and are often flared out.

Immatures are mottled brown overall with few distinguishing characteristics other than a vertically streaked chest and a yellowish eye. Immatures gain their adult plumage at 3 years of age.

The Northern Goshawk *laingi* subspecies, along with the two other Accipiter hawk species, Cooper's Hawk (*A. cooperii*) and Sharp-shinned Hawk (*A. striatus*), have short, rounded wings and an elongated tail that are well adapted for maneuvering and flying through forests in pursuit of prey. All Accipiters have a distinguishing flight pattern of flap-flap-flap-glide, which is different from most other raptors. Adult Northern Goshawk *laingi* subspecies are distinguished from both Cooper's and Sharp-shinned hawks by their larger size and their greyish colouration compared to the rusty-brown colouration of the other two species. Immature birds of all three species are similar in appearance, but can be differentiated by size and other subtle characteristics (e.g., immature goshawks have a white eye stripe).

Population Spatial Structure and Variability

Morphological, radio-telemetry and genetic studies indicate that there is mixing among geographically separated Northern Goshawk *laingi* subspecies populations and between *A. g. atricapillus* and *A. g. laingi* (McClaren 2005; USFWS 2007b).

Morphological variation among 55 adult and 58 juvenile goshawks captured at nest sites in southeast Alaska indicated that some birds' plumage characteristics overlapped with *A. g. atricapillus* (Flatten *et al.* 1998). However, these sampled birds were larger than birds from Vancouver Island and smaller than Alaskan birds from farther north, which were assumed to be *A. g. atricapillus*. In southeast Alaska, 45 captured adult goshawks were assigned to either *A. g. atricapillus* or *A. g. laingi*, based on their phenotype (Flatten 2002). The study found that 40% of the birds displayed characteristics of *A. g. laingi*, 33% of *A. g. atricapillus*, and 27% were intermediate between the two subspecies. Similarly on Vancouver Island, sampled birds were 38% *A. g. laingi*, 19% *A. g. atricapillus,* and 43% intermediate (Flatten and McClaren 2003). In total, only one third of adult and juvenile birds from southeast Alaska and Vancouver Island clearly had the dark phenotype as described by Taverner (1940) and Flatten and McClaren (2003). A study that compared birds captured from 43 nest areas on Vancouver Island and 42 nest areas in southeast Alaska found that Vancouver Island birds had significantly smaller wing chord, mass, culmen length, and hind claw length compared to *laingi* birds from southeast Alaska (Flatten and McClaren 2003). Male birds from Vancouver Island had the smallest average wing chords of all other western North American goshawks that were compared in the study.

Beebe (1974) indicated that goshawks from Vancouver Island were almost as dark as *A. g. laingi*, but fully one-third smaller in size. Beebe (1976) later suggested that they were distinct from both the *laingi* and *atricapillus* subspecies. Johnson (1989) measured 180 goshawk specimens from British Columbia and found no significant difference in size between Vancouver Island and Haida Gwaii birds, but found them both significantly smaller (by about 2-3%) than goshawks from the adjacent mainland. Whaley and White (1994) indicated that Vancouver Island goshawks were the smallest in North America, but not as small as Beebe (1974) had first indicated.

Radio-telemetry studies on Vancouver Island have located the *laingi* subspecies up to 100 km away from their nest sites (McClaren 2003), moving to breed on adjacent coastal islands (McClaren 2005), and wintering on the coastal mainland of British Columbia. These dispersal distances indicate that individuals are capable of moving far enough to mix with other geographically separate *laingi* subspecies populations, including perhaps the 60 km of open water that separates southeast Alaska and Haida Gwaii.

Genetic analyses of 454 individual goshawks compared sequence information from mtDNA control regions and fragment data from 10 nuclear microsatellite loci (Talbot *et al.* 2011). This analysis was used to assess relationships among 15 sampled population areas across the range of the *laingi* subspecies and adjacent areas. Initial findings suggested that there was current and historical gene flow among all populations of *A. g. laingi* and, in many cases, with *A. g. atricapillus* populations. It is likely that *laingi* subspecies population assemblages located in the Alexander Archipelago, Alaska, and coastal British Columbia interact through a metapopulation framework where populations are characterized by local extinctions and recolonizations over time. Other studies suggest that all goshawk populations along coastal British Columbia and Alaska interact as a metapopulation (Sonsthagen *et al.* 2012). Talbot *et al.* (2011) found that birds on Vancouver Island (n=119) demonstrated genetic affinities with *A. g. atricapillus* and may represent an area of intergradation because they display genetic signatures consistent with a contact zone between the two subspecies. Sonsthagen *et al.* (2012) also found Vancouver Island birds to have mismatched pairwise distributions with a significant raggedness index, suggestive of a secondary contact zone. Gene flow polarity estimates showed evidence that Vancouver Island has served as a recent and historical sink – an expected characteristic of a contact zone (Talbot *et al.* 2011). Small sample sizes precluded any analyses of goshawk populations along British Columbia's southern and mid-coast. Many of these genetic findings are supported by previous studies (Talbot *et al.* 2005; Talbot 2006).

The Northern Goshawk *A. g. laingi* Recovery Team recognized that an intergradation zone is likely along the range boundary of the two subspecies where genetic delineations are less clear, based on the boundary between coastal and interior forest habitats and prey assemblages (NGRT 2008). Further studies would provide a clearer understanding of genetic structuring of Northern Goshawk *laingi* subspecies populations.

Designatable Units

Much recent discussion has occurred by species' experts on whether designatable units should be established for the *laingi* subspecies, particularly for the Haida Gwaii population due to its small and genetically isolated population. Recent genetic analyses (e.g., Talbot *et al.* 2005, 2011; Sonsthagen *et al.* 2012) provide some convincing arguments that the Haida Gwaii subpopulation could meet criteria for discreteness and significance as stipulated in COSEWIC guidelines for recognizing designatable units (COSEWIC 2009), and thus could qualify as a designatable unit.

However, some of the genetic analysis findings suggest that Haida Gwaii birds may not be as genetically distinct or isolated as previously thought. For example, genetic data did not provide evidence that Haida Gwaii was a Wisconsin glaciation refugium for the *laingi* subspecies (Talbot *et al.* 2011). Although unique haplotypes were present in Haida Gwaii birds, partitions between them and those observed in samples from birds elsewhere were no deeper than those observed among haplotypes characterizing birds from the Alexander Archipelago in southeast Alaska – the geographically nearest subpopulation to Haida Gwaii. This suggests that there are similar genetic influences from immigrant birds to Haida Gwaii as those found on the Alexander Archipelago. In addition, Haida Gwaii birds did not have private alleles at microsatellite loci or exhibit differentiation at nuclear introns or exons, which would be expected if they were isolated in a refugium.

Still, the unique and rare haplotypes observed for Haida Gwaii birds suggest that perhaps their original source population differed from the source population(s) of other nearby *laingi* subspecies populations. Overall, contemporary gene flow between Haida Gwaii and other *laingi* subspecies populations is restricted, but does occur. Haida Gwaii appears to be a source population, providing more emigrant birds to other populations than it receives, and it is most closely genetically aligned with populations on the Alexander Archipelago and the former Kispiox Forest District on the northwestern mainland coast of British Columbia. Results from genetic studies estimate that five immigrants per generation enter the Haida Gwaii subpopulation (Sonsthagen *et al.* 2012), which is greater than the minimum one immigrant per generation guideline that is typically used to suggest that genetic distinction is maintained within a population. As such, available genetics and other information on movements of marked birds suggest that there is sufficient genetic interchange to consider the British Columbia population as a singular unit, rather than as a series of separate subpopulations. Further genetic studies with larger sample sizes are needed before accepting any change to the currently accepted DU structure for the *laingi* subspecies.

Special Significance

The *laingi* subspecies is a top avian predator in mature and old coastal rainforests and is considered an indicator species of these habitats. It is also a primary large-stick nest builder, regularly abandoning previously used nest structures, which in turn may be reused by other species such as large owls, Red-tailed Hawk (*Buteo jamaicensis*), Common Raven (*Corvus corax*), Great Blue Heron (*Ardea herodias*), American Marten (*Martes americana*) and squirrels (*Sciurus* spp.; Squires and Reynolds 1997; NGRT 2008).

On Haida Gwaii, the *laingi* subspecies was part of Haida culture and folklore and was often traditionally referred to as the "Blue Hawk", likely a result of its bluish-grey plumage (Guujaaw, pers. comm. 1998; NGRT 2008). The *laingi* subspecies is mentioned as a species of cultural concern in the Haida Land Use Vision and indicates that birds have played an integral role in building and maintaining the well-being of the land and Haida culture (CHN 2005). Further Aboriginal traditional knowledge for the subspecies may be available for future status report updates.

The *laingi* subspecies is also considered an important indicator of mature and old-growth forest condition, supply and distribution. As such, it has been included in several levels of provincial and regional land use planning, and wildlife and habitat management strategies and policies (e.g., British Columbia's Identified Wildlife Management Strategy (BC MWLAP 2004), the Haida Gwaii Strategic Land Use Agreement (Province of BC 2007), the Powell River Community Forest - Forest Stewardship Plan (FOPRCFL 2008), and an Ecosystem-Based Management strategy currently being implemented under British Columbia's central, south central, and north coast Land Use Orders (Province of BC 2009).

DISTRIBUTION

Global Range

Including all subspecies, the breeding range of the Northern Goshawk extends from Alaska east across Canada to Newfoundland, and southwest to central Mexico (Figure 1). The range boundaries for the *laingi* subspecies are inexact (NGRT 2008). It occurs only in the Pacific Northwest of North America and is found in coastal rainforests: in Alaska south of Glacier Bay National Park through the Alaskan mainland and southeast islands of the Alexander Archipelago (USFWS 2007b); in British Columbia (on Haida Gwaii, Vancouver Island, the coastal islands, and the coastal mainland west of the Coast Mountains; NGRT 2008); and likely in western Washington (Figure 2).

The Washington Department of Fish and Wildlife considers *A. g. atricapillus* as the only subspecies of Northern Goshawk known in the state (Desimone and Hays 2004; WDFW 2012). However, dark or "dusky" goshawk specimens that morphologically match the description of the *laingi* subspecies have been collected in various parts of western Washington (Jewett *et al.* 1953).

Canadian Range

In Canada, the entire range of the Northern Goshawk *laingi* subspecies occurs within British Columbia. The Canadian range boundaries are not precise, but the subspecies occurs in the coastal rainforests of Haida Gwaii, Vancouver Island, other British Columbia coastal islands and the coastal mainland west of the Coast Mountains (NGRT 2008).

The Northern Goshawk *A. g. laingi* Recovery Team suggests that the Canadian range of the *laingi* subspecies follows the distribution of the Coastal Western Hemlock (CWH) and Coastal Douglas-fir (CDF) biogeoclimatic zones in British Columbia (Green and Klinka 1994; NGRT 2008), though this should be revisited in light of recent genetic findings. Along British Columbia's coast, high elevational peaks and glaciated areas in the Coast Mountain Range likely create somewhat of a physical barrier between *A. g. laingi* and *A. g. atricapillus* populations (NGRT 2008). However, in lower elevational areas along the Coast Mountains, drier CWH subzones link coastal rainforests to drier interior forests. The drier CWH subzones/variants are thought to be transitional between the two subspecies (NGRT 2008).

As the range boundaries for *laingi* subspecies are imprecise, the exact percentage of the global distribution within Canada is currently unknown (NGRT 2008). The Northern Goshawk *A. g. laingi* Recovery Team estimated that about 50–60% of the total range of the *laingi* subspecies occurs within Canada, when western Washington is included in its range (NGRT 2008).

The estimated extent of occurrence (EO) for the Canadian population was generated through a Geographic Information System (GIS) query of the area of a minimum convex polygon (convex hull) that contained all known Northern Goshawk *laingi* subspecies nest territories in British Columbia. The EO was estimated at 190,028 km^2. This calculation is likely an underestimate as it does not contain unknown nest territories that likely exist outside the polygon.

An index of area of occupancy (IAO) for the Canadian population cannot be calculated with certainty. Applying a 2 x 2 km cell grid around each of the estimated 370-415 nests (see **Abundance**) yields an IAO value ranging from 1480 to 1660 km^2. However, the actual IAO would exceed 2000 km^2, because home range of a nesting pair is greater than a 2 x 2 km cell.

Figure 1. Overall breeding range of the Northern Goshawk (all subspecies) in the Western Hemisphere. Adapted from NatureServe (2012).

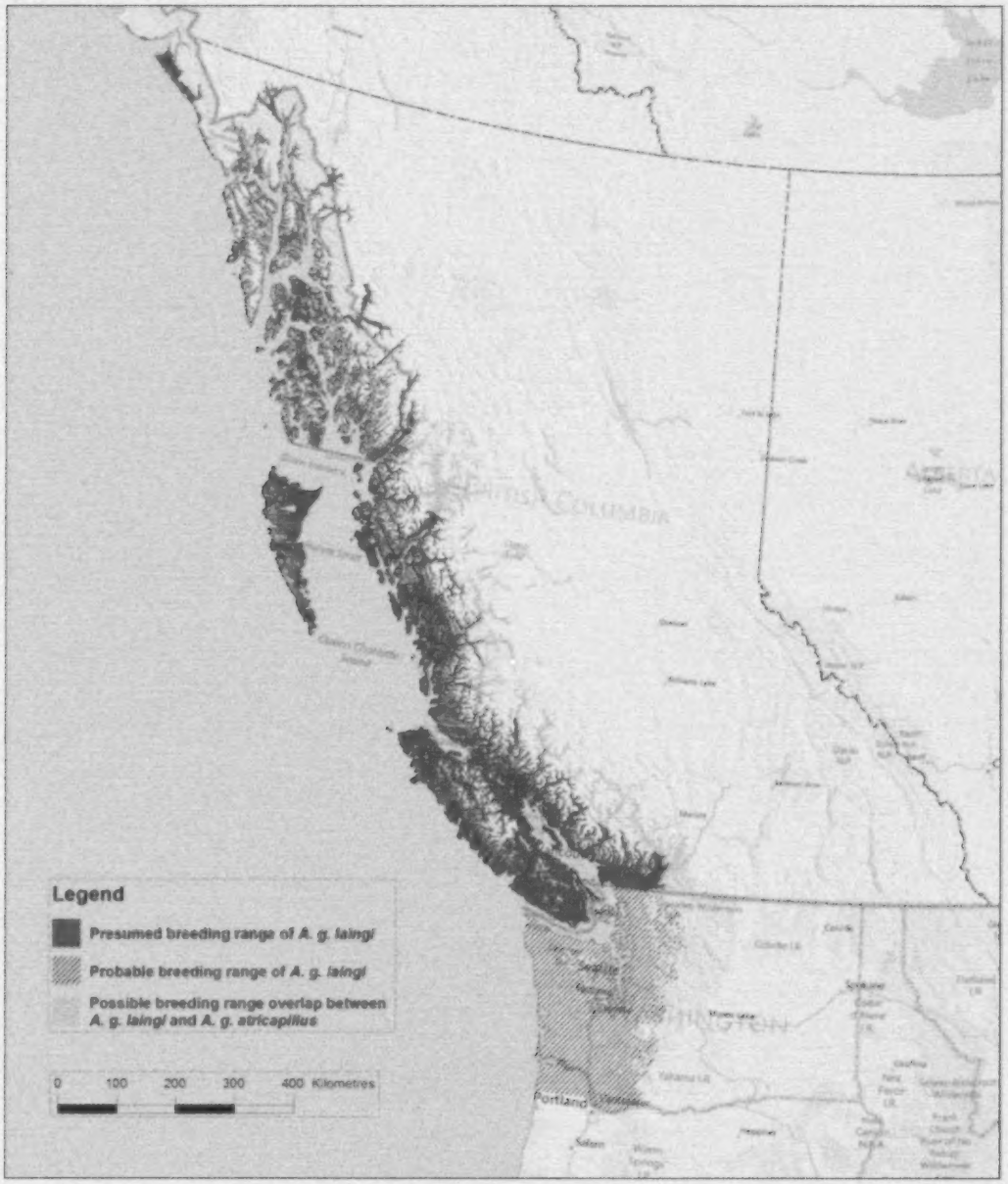
Legend
Presumed breeding range of A. g. laingi
Probable breeding range of A. g. laingi
Possible breeding range overlap between A. g. laingi and A. g. atricapillus
0 100 200 300 400 Kilometres
Portland

Figure 2. Breeding range of the Northern Goshawk *laingi* subspecies in British Columbia (adapted from NGRT 2008; graphic by Alain Filion). The map does not incorporate results from recent genetic analyses, which suggest a different area of overlap between the two subspecies.

HABITAT

Breeding Habitat

The Northern Goshawk *laingi* subspecies selects breeding habitat based on forest stand structure rather than on stand age or tree species composition (NGRT 2008). Although it may breed in younger, more even-aged stands, it tends to choose breeding areas that are dominated by mature or old-growth trees, or stands with similar structural characteristics (e.g., relatively closed, multi-layered canopies with some large live trees and snags; Iverson *et al.* 1996; McClaren 2003; Doyle 2005; Manning *et al.* 2008c).

Larger volume forests with high canopy-closure, multi-storied stands, and the presence of trees with sufficient branch structure to support nests are important breeding habitat features (Iverson *et al.* 1996; Flatten *et al.* 2002; Lewis *et al.* 2003; McClaren 2003; Doyle 2005; Manning *et al.* 2008c). Larger volume stands of maturing, mature and old-growth trees typically have forest structure complexities and attributes that provide suitable nesting habitat, more so than younger, homogenous, even-aged stands. Relatively closed canopies (60-80%) provide protection for young from predators and provide thermal cover, while multi-storied canopies provide more open spaces through the mid- and lower canopy that allow clear flight paths for hunting and striking prey. Large trees with well-developed branches or smaller trees with deformities (e.g., multi-forked tops or mistletoe structures) that can securely hold nests are typically selected as nest trees.

The *laingi* subspecies tends to breed in larger, intact patches of forest rather than small isolated stands (Iverson *et al.* 1996; McClaren 2003; Doyle 2005; Manning *et al.* 2008b). On Vancouver Island, nests were often located >200 m from hard edges and in stands that were >100 ha in size (Ethier 1999; McClaren *et al.* 2005). In southeast Alaska, monitored radio-tagged adults around known nest territories indicated that patch sizes of up to 40 ha were too small to adequately maintain the long-term occupancy of nesting pairs (Flatten *et al.* 2001). However, small forest openings, such as those created by patches of fallen trees or in old road and railway rights-of-way, are often associated with nest sites (Iverson *et al.* 1996; Chytyk and Dhanwant 1999; Manning *et al.* 2006).

Breeding home range has often been described as a hierarchical arrangement of use-areas and includes: the nest area, post-fledging area, and foraging area (Reynolds *et al.* 1992; Iverson *et al.* 1996; McClaren 2003; McClaren *et al.* 2005; Figure 3). Each is described below.

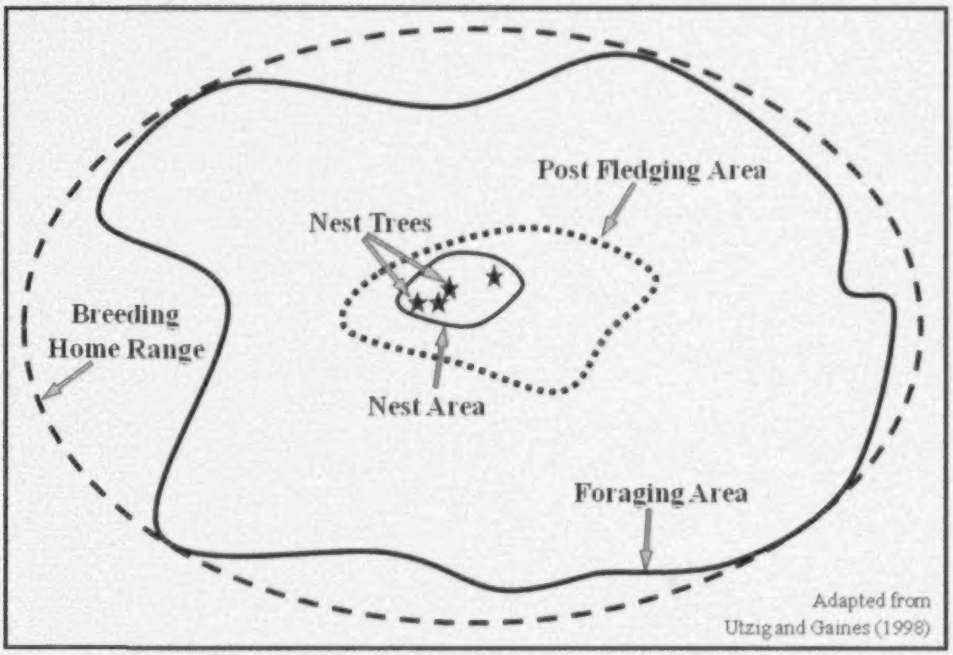

Figure 3. Conceptual diagram of the hierarchal components of a Northern Goshawk *laingi* subspecies breeding home range.

Nest Area

The nest area is the forest stand that immediately surrounds the active nest tree, alternate nest tree(s), roost trees, and prey plucking-posts (Reynolds *et al.* 1992; Figure 3). The nest area is the immediate core use area where most adult courtship behavior occurs and fledglings first learn their flying and hunting skills.

Nest areas vary in size, shape and location, depending on the topography, availability of suitable habitat and the number of nest trees present in the stand. In southeast Alaska, radio-telemetry studies found nest areas to range from 5-15 ha in size (Flatten *et al.* 2001). On Vancouver Island, nest areas were generally located on the bottom two-thirds of moderate slopes, at elevations below 900 m, and on all aspects (McClaren 2003). Nest areas were generally located in forest patches that contain larger trees and higher volume wood than the surrounding stand (Lewis *et al.* 2003; McClaren 2003). Studies in southeast Alaska found that nest areas contained more old forest, higher canopy cover, greater representation of multi-storied stands, more Western Hemlock (*Tsuga heterophylla*), fewer large openings, and less forest/non-forest edge than random sites of similar size (Iverson *et al.* 1996; Lewis 2005).

On Vancouver Island, nest areas (n = 66) were found in both old-growth stands (70.2%) and in second-growth stands (29.8%; McClaren 2003). Younger second-growth stands (50-93 years old) that were used as nest areas typically had Douglas-fir (*Pseudotsuga menziesii*) as the leading tree species and a high site index, indicating high-quality nutrient and moisture regimes that promote fast tree growth (i.e., increased canopy height and crown closure; Manning *et al.* 2005). On Haida Gwaii, second-growth stands are not thought to develop characteristics suitable for nesting by the subspecies until they attain an age of 100 years (Doyle 2006b).

Nest trees tend to be one of the larger trees in the nest area (Iverson *et al.* 1996; Ethier 1999; McClaren 2003; Manning *et al.* 2008c). On Vancouver Island, nest trees had a mean dbh (diameter at breast height) of 70.7 cm (± 2.9 cm; n = 131; McClaren 2003). Mean nest tree height was 39.0 ± 1.6 m, while mean nest height was 19.4 ± 0.8 m. In southeast Alaska, nest trees had a mean dbh of 69 ± 3.7 cm (Lewis *et al.* 2003). Larger trees provide structural support and platforms for nests, including: strong lateral branches, stem crotches, defects, or mistletoe-like structures that facilitate and support the construction of large stick nests.

On Vancouver Island, most nest trees (n = 131) were Douglas-fir (59%), Western Hemlock (30.5%) and Red Alder (*Alnus rubra*; 6.9%), but Sitka Spruce (*Picea sitchensis)*, Amabilis Fir (*Abies amabilis*), and Western Redcedar (*Thuja plicata*) were also used (McClaren 2003). Almost all nest trees were live (McClaren 2003). In southeast Alaska, nest trees (n = 37) were mostly Sitka Spruce (54%) and Western Hemlock (41%; Flatten *et al.* 2002). In general, the variety of nest tree species chosen by the *laingi* subspecies suggests that the birds select for forest and nest tree structure, not nest tree species (McClaren 2003).

The Northern Goshawk *laingi* subspecies builds and uses one or more alternate nests within their nest area (Iverson *et al.* 1996; McClaren 2003). The use of alternate nests is thought important for reducing the exposure to disease and parasites found in old nests (Squires and Reynolds 1997) and for strengthening the pair bond by both adults participating in nest building activities together (E. McClaren, pers. comm. 2004). On Vancouver Island, the mean distance between alternate nests was 274.0 ± 37.2 m (n = 65; McClaren *et al.* 2005). About 50% of all alternate nests were within 200 m of one another and 90% were within 500 m of one another (McClaren 2003). On average, pairs used nest trees for 1.6 years (n = 72; range 1 to 6 years). In British Columbia, some territories have been documented being used for over 15 years (E. McClaren unpubl. data; Doyle 2012).

Post-fledging Area

The post-fledging area surrounds and includes the nest area and is the area where the adult female mainly hunts during the early nesting season and where fledglings hone their hunting skills while still being fed and protected by the adults until they gain their independence (Reynolds *et al.* 1992; Kennedy *et al.* 1994; Figure 3).

Relatively few data are available that quantify attributes of post-fledging habitat. In southeast Alaska, post-fledging habitat in 240-ha circles around *laingi* subspecies nests (n = 34) was compared to the habitat in the surrounding 4000-ha areas (Iverson *et al.* 1996). Productive old-growth forest was 10% greater within the post-fledging areas than in the surrounding 4000-ha plots.

On Vancouver Island, radio-tagged fledglings (n = 15) were monitored during a 2-year period (McClaren *et al.* 2005). During the first 3 weeks after fledging, 93% of fledgling locations (n = 236) were within 200 m of the nests. During the next four weeks, only 42% of the fledgling locations were within 200 m of the nests. In general, as the fledglings aged, they tended to move farther away from their nest tree. However, they did not continue to expand their post-fledging area indefinitely until they departed from nest area, but instead continued to return to their nest tree for short periods of time.

The estimated average size of post-fledging areas for *laingi* subspecies ranges from 19.3 – 59.2 ha (Iverson *et al.* 1996; McClaren *et al.* 2005; Titus *et al.* 2006; Mahon 2009b). In southeast Alaska, circular post-fledging areas of 707 ha were derived from the average distance of 1500 m that radio-tagged juveniles moved prior to dispersal (Titus *et al.* 2006). Within these post-fledging areas, 39% of the habitat was medium- and high-volume old-growth forest, 45% was non-forested or non-commercial forest, 8% was low-volume forest, and 4% was clearcuts.

Foraging Area

The foraging area surrounds the post-fledging area and is the area where the adult male mainly hunts throughout the breeding season and the adult female hunts during the late breeding season (Figure 3). The foraging area is typically defended year-round by the adult male against rival males (Flatten *et al.* 2001; Titus *et al.* 2002). The adult female may remain within the foraging area until the onset of winter weather conditions reduces the availability of prey (McClaren 2003).

The *laingi* subspecies tends to forage in mature and old forest habitats (Iverson *et al.* 1996; McClaren 2003; Titus *et al.* 2006). These preferred habitat types are characterized by closed canopies, relatively large diameter trees, and open understorys that provide open subcanopy flight paths and access to prey (Cooper and Stevens 2000; USFWS 2007b; NGRT 2008). However, preferred foraging habitat likely varies both regionally and temporally, and also by sex and perhaps individual birds or pairs (USFWS 2007b; Mahon *et al.* 2008). Radio-telemetry data indicate that birds also forage in habitats outside their breeding areas, including: forest edges, estuaries, coastal shorelines and elevations >900 m (Iverson *et al.* 1996; McClaren 2003; Titus *et al.* 2006).

In southeast Alaska, 2333 locations from 67 radio-tagged birds (35 adults, 3 immatures and 29 juveniles) were tracked during 1992 and 1996 (Titus *et al.* 1994; Iverson *et al.* 1996; summarized in USFWS 2007b). Although there was notable variation among individuals, foraging *laingi* subspecies tended to use very high/high-volume and medium-volume old forest cover types more often than would be predicted by their availability. Mature sawtimber, older scrub forest (e.g., old forest located on inoperable sites such as rocky outcrops), and low-volume productive old forest were used in proportion to their relative availability, but notably less than the two higher-volume cover types. Non-forest, clearcut and alpine cover types appeared to be mostly avoided relative to their availability.

On Vancouver Island, 259 locations from 63 radio-tagged *laingi* subspecies were collected between 1996 and 2001 (McClaren 2003). Tracked birds were located in old-growth forests 74% of the time, second-growth forests 20% of the time, and mixed old- and second-growth forests 4% of the time. Detections in old-growth forests were notably higher than would be predicted by their availability across the landscape.

Preferred foraging habitat may be selected more for prey availability than for the amount of prey present (Beier and Drennan 1997; Boxton 2002). Prey availability is likely affected by the amount of vegetative cover in both the subcanopy and understory (Iverson *et al.* 1996; Doyle 2006b; USFWS 2007b; T. Mahon, pers. comm. 2011). Goshawks use the advantage of surprise when hunting and often use vegetative cover to conceal their approach to prey (Titus *et al.* 1994; Squires and Reynolds 1997). However, dense vegetation provides escape cover for prey and can interfere with *laingi* subspecies flight paths and maneuverability, thereby reducing overall hunting success (Squires and Reynolds 1997; USFWS 2007b).

Habitat Trends

The current amount of suitable habitat has been reduced from historical (pre-industrial) levels due to large-scale forest harvesting activities (UFWS 2007; NGRT 2008). However, the precise amount of this reduction is unknown. Estimates for the amount of habitat loss have been calculated using nesting and foraging habitat suitability models and a territory analysis model (Smith and Sutherland 2008; Mahon *et al.* 2008) and forest cover analyses (USWFS 2007).

A nesting and foraging habitat model based on Habitat Suitability Index (HSI) methodology was developed for all of coastal British Columbia (Mahon *et al.* 2008). This preliminary habitat model was then modified to reflect regional habitat differences and applied across all four goshawk conservation regions: Haida Gwaii, North Coast, South Coast and Vancouver Island, and subsequently analyzed to estimate the total amount of habitat loss for coastal British Columbia (Smith and Sutherland 2008). As noted below, most of these estimates include "low quality" suitable habitat for the *laingi* subspecies.

Prior to field verification of the accuracy of these habitat models, a preliminary analysis found that the North Coast conservation region presently consisted of 35% nesting habitat (including low-quality habitat) and 88% foraging habitat (including low-quality habitat; Smith and Sutherland 2008). On the North Coast, current levels of nesting habitat were 35% lower than historical (pre-industrial) levels and 20% lower for foraging habitat. Different habitat quality threshold scenarios were applied to generate the estimated number of current potential nesting territories for the North Coast. Depending on the threshold scenario that was applied, the number of current potential nesting territories ranged from 14 to 325. Historically, the analysis suggested the North Coast had 74 to 341 potential nesting territories.

The South Coast conservation region consisted of 44% nesting habitat and 42% foraging habitat, including low-quality habitat (Smith and Sutherland 2008). Current levels of nesting habitat were 52% lower than historical (pre-industrial) levels and 31% lower for foraging habitat. Current potential nesting territories for the South Coast ranged from 43 to 280; while historical potential nesting territories ranged from 255 to 316.

The Vancouver Island conservation region consisted of 17% nesting habitat and 35% foraging habitat (including low quality habitat); while historically (pre-industrial), the conservation region consisted of 38% nesting habitat and 51% foraging habitat (Smith and Sutherland 2008). This represents a reduction of 55% in nesting habitat and 31% in foraging habitat from historical times. Current potential nesting territories for Vancouver Island ranged from 77 to 447; while historical potential nesting territories ranged from 361 to 469, depending on which habitat quality threshold scenario was applied.

Analysis for the Haida Gwaii conservation region was presented only for the current number of territories and habitat amounts using the moderate habitat-quality threshold scenario (Smith and Sutherland 2008). Under this scenario, there were 65 current potential nesting territories for Haida Gwaii; this conservation region currently consisted of 58% suitable nesting habitat and 89% foraging habitat.

The preliminary Northern Goshawk *laingi* subspecies HSI-based habitat models were subsequently field verified between 2009-2011 in each of the four conservation regions (Mahon 2009a, 2011; Doyle *et al.* 2010). The objectives of the field assessments were to provide estimates of model accuracy and to provide data to evaluate and refine the models to improve their performance. Field verification found the accuracy of these habitat models decreased at finer spatial scales mostly due to errors in forest cover polygon data (Mahon 2009a, 2011). In general, forest cover data used for the model was believed to be relatively good at the broad landscape-scale (e.g., landscape unit or forest district-level), but poor to moderate at the polygon level (e.g., stand or cutblock level; Doyle *et al.* 2010; Mahon 2009a). As a result, field verification concluded that the habitat models should be applied cautiously at finer spatial resolutions and scales. At some fine scales, the application of the model may not be appropriate for certain activities due to its low accuracy at smaller scales (Mahon 2009a).

On Haida Gwaii, a preliminary analysis of 17 nest territories had between 41 – 79% high- and medium- quality foraging habitat (B. Wijdeven, pers. comm. 2012). However, once future forest harvesting was projected under the recent Land Use Order, only 4 territories contained 40% high- and medium- quality foraging habitat, while the other 13 territories ranged from 24 – 39% high- and medium- quality foraging habitat.

A trend analysis for *laingi* subspecies habitat was completed for Vancouver Island, Haida Gwaii and southeast Alaska using provincial and state forest cover databases (USFWS 2007b). Historically (pre-industrial times), Vancouver Island provided about 37% (2.8 million ha) of all habitat, Haida Gwaii provided 11% (0.8 million ha) and southeast Alaska provided 52% (3.9 million ha; Table 1). By 2005, the amount of habitat on Vancouver Island had decreased by 43% to 1.6 million ha, Haida Gwaii decreased by 25% to 0.6 million, and southeast Alaska decreased by 10% to 3.5 million ha. Consequently, among the three areas in 2005, Vancouver Island provided about 27% of all habitat, Haida Gwaii provided 11% and southeast Alaska provided 61%. When current and projected harvesting and habitat recovery rates were extrapolated to the year 2100, the amount of habitat on Vancouver Island was projected to decrease by 31% from 2005 to 1.1 million ha, Haida Gwaii decreased by 17% to 0.5 million and southeast Alaska decreased by 11% to 3.1 million ha. Overall, habitat is projected to decline by about 20% from 2005 to 2100, which is equivalent to a loss of about 4% over three generations.

Since European settlement, about 3% of the *laingi* subspecies' range in Canada has been permanently lost to urbanization and agriculture, mostly along the southeast coast of Vancouver Island and British Columbia's lower mainland (NGRT 2008). However, there is little evidence to suggest that this particular habitat loss has resulted in any significant range contraction.

Table 1. Estimated amount of historical (pre-industrial), current and future Northern Goshawk *laingi* subspecies habitat for Vancouver Island, Haida Gwaii and southeast Alaska, based on forest cover attributes.

Area	Estimated amount of Northern Goshawk *laingi* subspecies forest habitat*		
	Historical	2005	2100
Vancouver Island	2.8 million ha	1.6 million ha	1.1 million ha
Haida Gwaii	0.8 million ha	0.6 million ha	0.5 million ha
Southeast Alaska	3.9 million ha	3.5 million ha	3.1 million ha
Total	**7.5 million ha**	**5.7 million ha**	**4.7 million ha**

* Source: USFWS (2007b).

BIOLOGY

The Northern Goshawk *laingi* subspecies is one of the most intensely studied raptors in North America. All information presented below is from studies specifically on the *laingi* subspecies from Vancouver Island, Haida Gwaii and southeast Alaska. In some cases, where information on *A. g. laingi* is lacking, information on *A. g. atricapillus* has been substituted and is duly noted.

Life Cycle and Reproduction

Laingi subspecies birds are resident, short-distance, non-migratory wanderers. Males primarily remain on or near their nest territories year-round, while females tend to make short-distance movements to mostly lower elevations in winter (McClaren 2003; Iverson *et al.* 1996). Males typically have higher nest territory fidelity than females (McClaren 2003; Flatten *et al.* 2001). On Vancouver Island, 24.4% of radio-tagged females (n = 41) returned to their original nest areas in subsequent years (McClaren 2003). Female turnover rates within nest territories were 78.9% (n = 57); one territory had 6 different females in as many years. In southeast Alaska, adult females moved to new nest territories 35.7% (n = 18) of the time, while all males (n = 11) retained their territory fidelity (Flatten *et al.* 2001, 2002; Titus *et al.* 2002, 2006).

Weather conditions and prey availability in late winter and early spring likely influence the timing of breeding each year (Bloxton 2002; Manning *et al.* 2004; Wiens *et al.* 2006; Doyle 2008a). Males provide females with most of their food supply during the pre-laying, incubation, and brooding periods (Iverson *et al.* 1996; NGRT 2008). Thus, if the male is unable to provision the female adequately, she may delay or abort any nesting attempt for that year (Bloxton 2002; Wiens *et al.* 2006). In addition to causing breeding delays, cool wet weather during the early nesting season also causes egg-chilling and direct nestling mortality due to exposure (Kostrzewa and Kostrzewa 1990; Keane *et al.* 2006).

During average years in British Columbia, nesting typically begins in March and April, egg laying occurs near the beginning of May, hatching occurs near the beginning of June, fledging occurs in early July, and departure from the nest area occurs in late August (McClaren *et al.* 2005; Table 2). Fledglings are fed by the adults for 35–55 days.

Table 2. Northern Goshawk *laingi* subspecies nesting chronology for British Columbia (adapted from Chytyk and Dhanwant 1999).

Event	Time Period
Courtship	Last week of February to first week of April
Nest building	March through April
Egg laying	Last week of April and the first week of May
Hatching	Last week of May and the first week of June
Fledging	First two weeks of July
Dispersal	Last two weeks of August

Most Northern Goshawks initiate breeding at ≥3 years, once they attain their adult plumage, but this varies by population (Squires and Reynolds 1997; Kenward 2006). Females typically breed earlier than males and are known to breed as subadults (1-2 years old; Squires and Reynolds 1997; McClaren 2003). However, it is unknown how prevalent subadult breeding is for the *laingi* subspecies (F. Doyle, pers. comm. 2012). In Arizona, a long-term study of 69 marked *A. g. atricapillus* juveniles bred for the first time at 4.2 ± 0.3 years old (females) and 3.9 ± 0.3 year old (males; Wiens 2004). Generation time for the *laingi* subspecies is unknown, but is estimated at 5 years, based on a study of goshawks in Europe (Krüger 2007).

Average clutch size for the *laingi* subspecies is unknown (NGRT 2008), but it is likely two to four eggs, as with *A. g. atricapillus* (Squires and Reynolds 1997). The *laingi* subspecies only has one clutch per season and typically will not attempt to re-nest, even if nest failure occurs early in the nesting season (E. McClaren, pers. comm. 2005; USFWS 2007b).

Mean nest productivity for *laingi* subspecies ranges from 1.6 to 2.0 fledglings per successful nest, depending on the region. On Vancouver Island, mean nest productivity was 1.6 ± 0.1 fledglings (n = 141) between 1994 and 2002 (McClaren 2003) and 1.8 ± 0.1 (n = 15) between 2003 and 2008 (Manning *et al.* 2008c). On Haida Gwaii, mean nest productivity was 1.6 ± 0.5 fledglings (n = 21; Doyle 2012), while in southeast Alaska, nest productivity was 2.0 fledglings (n = 113; Flatten *et al.* 2001). Lifetime reproductive success for *laingi* subspecies is unknown (NGRT 2008).

The maximum lifespan for *A. g. laingi* is unknown, but the maximum age reported for wild *A. g. atricapillus* is >15 years (R.T. Reynolds, pers. comm. cited in NGRT 2008). In southeast Alaska, radio-tagged *laingi* birds had a 0.72 ± 0.16 (n = 39) mean annual survivorship for adults (Iverson *et al.* 1996), and 0.59 ± 0.10 for adult males and 0.74 ± 0.06 for adult females (Flatten *et al.* 2002). Most adult mortality on Vancouver Island and in southeast Alaska occurs in winter (Titus *et al.* 2002; McClaren 2003), when prey availability is more limited and harsh weather conditions may impact bird health, leading to starvation. In southeast Alaska, the apparent annual survival rate for juveniles was estimated at 0.44 based on the number of radio-tagged juveniles that returned to the study area during the next year (Broberg 1997). On Vancouver Island, 37.5% (n = 8) of radio-tagged fledglings died prior to dispersing from the nest area (McClaren *et al.* 2005).

Physiology and Adaptability

A. g. laingi is generally darker in plumage and smaller in size than *A. g. atricapillus* (Taverner 1940; Johnson 1989; Flatten *et al.* 2002). Darker plumage may be an adaptation for inhabiting darker, denser coastal rainforests (NGRT 2008). Within dimly lit coastal habitats, darker plumage may increase camouflage and improve the bird's hunting success (NGRT 2008). Additionally, the smaller size of the *laingi* subspecies may enhance its maneuverability while hunting within the dense vegetation that is characteristic of coastal rainforests.

Diet

The Northern Goshawk *laingi* subspecies is a generalist predator of medium-sized birds and mammals (Squires and Reynolds 1997; Kenward 2006; USFWS 2007b; NGRT 2008). Diet varies by region, season, and individual bird (NGRT 2008). On Vancouver Island, analyses of prey items at nests found that the most common prey items to be Red Squirrel (*Tamiasciurus hudsonicus*), Varied Thrush (*Ixoreus naevius*), Steller's Jay (*Cyanocitta stelleri*) and Northern Flicker (*Colaptes auratus*; Ethier 1999; Manning *et al.* 2005).

At nests on Haida Gwaii, the introduced Red Squirrel constituted 61% of total prey biomass (Doyle 2005). Unidentified large passerines accounted for 6% of prey biomass. Identified passerines, which included thrush (*Catharus*) spp., Steller's Jay, American Robin (*Turdus migratorius*), and Northwestern Crow (*Corvus caurinus*), totalled 3% of prey biomass, while Sooty Grouse (*Dendragopus fuliginosus*) contributed over 17% of prey biomass. Various woodpecker spp. contributed 3% of prey biomass. Other small mammals like rats (*Rattus* spp.) and shrews (*Sorex* spp.) are less commonly taken (Roberts 1997).

In southeast Alaska, the diet appears to be dominated by birds (e.g., Varied Thrush, Steller's Jay, grouse, Northwestern Crow, woodpeckers, Sharp-shinned Hawk, and ptarmigan (*Lagopus* spp.), followed by small mammals (mostly Red Squirrels, though some mice, voles, hares and marmots were also found; Titus *et al.* 1994; Lewis *et al.* 2004, 2006).

Little information is available on the winter diet of the *laingi* subspecies (NGRT 2008); however, on Haida Gwaii Red Squirrel and Sooty Grouse are thought to be the most important prey species (Doyle 2006a).

Home Range

Breeding home ranges include the nest tree area, post-fledging area and the foraging area; all of which are areas that are used by the adults and dispersing young to hunt in (NGRT 2008). Breeding home ranges vary in size across regions and among individual pairs according to their experience, hunting skills, brood size, and the availability of prey (Kennedy *et al.* 1994; Squires and Reynolds 1997). Individuals within a pair may have entirely different foraging areas from one other (USFWS 2007b), and they may also change their foraging areas among seasons and years (Titus *et al.* 1994; McClaren 2003). In general, home ranges of *A. g. laingi* are thought to be larger than for *A. g. atricapillus* because prey availability and abundance are likely lower in coastal habitats than interior habitats (Crocker-Bedford 1990, 1994; Titus *et al.* 1994; USFWS 1997; McClaren *et al.* 2009).

On Vancouver Island, the average distance between nest territories was 6.9 km (McClaren 2003), which approximated a 3800-ha breeding home range size (McClaren *et al.* 2009). On Haida Gwaii, a mean inter-territorial distance of 10.8 km (Doyle 2005) was used to calculate an estimated 9200-ha breeding home range size (McClaren *et al.* 2009). NGRT (2008) produced estimated home range sizes of 9200 ha for the north coast and 3800 ha for the south coast. In southeast Alaska, breeding home ranges were estimated at 3900 ha for females and 4300 ha for males (Titus *et al.* 2006).

Non-breeding (winter) home ranges in southeast Alaska were notably larger than during the breeding season at 11,800 ha for females and 11,900 ha for males (Titus *et al.* 2006). Another study in southeast Alaska, found year-round (breeding and winter) home ranges were 47,563 ha for females and 15,719 ha for males (Lewis and Flatten 2004). The difference in year-round home range sizes between the sexes likely reflects longer-distance movements by females, which appear to be less tied to individual nesting areas during the non-breeding season than males (USFWS 2007b). In comparison, males appear to remain largely resident in or near their nest territories, although they tend to increase their area of use in winter (Lewis and Flatten 2004; McClaren 2003).

Territory Occupancy

Estimates of territorial occupancy rates are variable in Northern Goshawks, depending on field methods that affect detection rates (e.g., use of telemetry, call playback, number of site visits; see Boyce *et al.* 2005). On Vancouver Island, annual occupancy rates for nest territories averaged 54.6% (n = 163; range 40% to 100%; McClaren 2003). Another study on Vancouver Island had an average annual occupancy rate of 36.5 ± 6.3% (n = 63; range 23% to 54%; Manning *et al.* 2008). On Haida Gwaii, annual occupancy rates averaged 46.3 ± 9.8% (n = 59; range 13% to 80%; Doyle 2012). In southeast Alaska, nest territories had an annual occupancy rate of 45% (n = 283; Flatten *et al.* 2001).

On Vancouver Island, an analysis of Northern Goshawk *laingi* subspecies territories (n = 39) found that the amount of mature and old forest did not significantly influence nest territory occupancy or productivity at any distance from the nest (McClaren and Pendergast 2003). However, there was a strong, but insignificant, correlation between the amount of >120-year-old forest within 800 m radius (~200 ha) of the territory centroid. Nest areas on Vancouver Island within fragmented landscapes (patches <50 ha surrounded by unsuitable habitat) had significantly lower occupancy rates (30.3%) than nest areas in contiguous old-growth forests (63.3%; $\chi_1^2 = 10.6$, $P = 0.001$) and contiguous second-growth forests (55.0%; $\chi_1^2 = 4.5$, $P = 0.03$; McClaren 2003). The lack of forest fragmentation of nesting areas was likely the most important factor that contributed to territory suitability and occupancy on Vancouver Island (McClaren and Pendergast 2003).

On Haida Gwaii, territory occupancy showed little or no trend with an increased area of mature or old-growth forest (Doyle 2009).

There are few data that quantify the minimum amount of mature and old habitat required in a nest territory to support a breeding pair of *laingi* subspecies (Mahon *et al.* 2008). An analysis of consistently occupied nest territories on Vancouver Island and Haida Gwaii found that these regularly used territories had at least 70% suitable foraging habitat (Daust *et al.* 2010). On Haida Gwaii, there was a correlation between occupancy and territories that contained 40% mature forest and a weaker correlation between occupancy with territories that contained 60% mature forest (Doyle 2005). In coastal British Columbia, nest territory areas that had 60% mature and old habitat were rated as having high probability of territory occupancy, territories with 40% were rated as moderate probability, and those with 20% were rated as low probability (Mahon *et al.* 2008). However, in general, minimum habitat requirements for the amounts of mature and old forest habitat for successful *laingi* subspecies territories likely vary regionally depending on annual prey abundance and availability (Mahon *et al.* 2008).

Dispersal and Migration

The Northern Goshawk *laingi* subspecies is considered to be non-migratory (Taverner 1940; Beebe 1974). However, they are likely better described as resident, short-distance, non-migratory wanderers. The degree to which *laingi* birds wander varies annually, likely depending on food supplies and winter weather conditions (Iverson *et al.* 1996; McClaren 2003). In some years, adult birds may move from breeding home ranges to distant winter home ranges, while in other years they remain within their breeding home ranges year-round.

There are few data for adult dispersal behavior for the *laingi* subspecies. On Vancouver Island, 80% of radio-tagged birds (n = 68) stayed within 30 km of their nests year-round and simply expanded their breeding home ranges during the winter (McClaren 2003). Some birds moved to distinct wintering areas up to 100 km away from their nest sites (McClaren 2003), including two that moved to the coastal mainland of British Columbia (McClaren 2000, 2001). On Vancouver Island, adult females were located 11.4 ± 1.1 km (n = 178) from their breeding sites during the winter, while males were located 15.7 ± 2.8 km (n = 81; McClaren 2003).

In southeast Alaska, at least 74% of radio-tagged birds (n = 38) remained in the region throughout the winter (ADFG 1996). Again in southeast Alaska, 100% of males (n = 11) exhibited fidelity to nest territories, while only 56% of females (n = 18) exhibited fidelity during a 7-year study (Flatten *et al.* 2001, 2002; Titus *et al.* 2002, 2006). The difference in fidelity rates between males and females may reflect nest site scarcity for males and food stress for females (Iverson *et al.* 1996).

Females may also disperse during the breeding season as a result of poor-quality nesting areas, the death or departure of a mate, or low food availability (NGRT 2008). In southeast Alaska, about 45% of radio-tagged adult females (n = 19) exhibited breeding dispersal (Iverson *et al.* 1996). Female breeding dispersal was believed to be related to food stress, as over-winter survival was high (0.96) for females that dispersed, but low (0.57) for females that did not.

In southeast Alaska, radio-tagged juveniles (n = 14) dispersed on average 63 km (range 11 to 163 km) from their nest sites (Titus *et al.* 1994). Following initial nomadic movements, juveniles often established use areas in late fall and winter where they were consistently relocated. Juvenile movements included flights across large water crossings. Both juvenile and adult birds are thought to move among the islands and the mainland across their entire range (McClaren 2005; M. Robus, pers. comm. 2006 cited in USFWS 2007b). Recent genetic analysis demonstrates that there is intermixing among subpopulations (Talbot *et al.* 2005, 2011; Sonsthagen *et al.* 2012), indicating individual birds are at least occasionally dispersing farther than radio-telemetry studies might suggest.

There are no data for juvenile natal fidelity, but no marked juveniles from Vancouver Island or southeast Alaska have been observed post-dispersal in their natal breeding areas (McClaren 2003; C. Flatten, unpubl. data cited in NGRT 2008).

Interspecific Interactions

The impact of interspecific competition for nest sites and food supplies from other raptor species on Northern Goshawk *laingi* subspecies populations is unknown (NGRT 2008), but it is thought to be minor. Several species of hawks, owls, and mammals have diets that partially overlap with the diet of the *laingi* subspecies, including: Red-tailed Hawk, Great Horned Owl (*Bubo virginianus*), Barred Owl (*Strix varia*), American Marten and Raccoon (*Procyon lotor;* Johnsgard 1990; Squires and Reynolds 1997). Species that share the most similar diet are Cooper's Hawk and Sharp-shinned Hawk (Reynolds and Meslow 1984). However, the larger *laingi* subspecies is presumably dominant, and has been known to prey upon Sharp-shinned Hawks (Titus *et al.* 1994). Barred Owl and Great Horned Owl do not occur on Haida Gwaii, while Cooper's Hawk occurs primarily on the southern portions of Vancouver Island and the southern mainland coast of British Columbia (Dunn and Alderfer 2008).

The *laingi* subspecies has few natural predators due to their relatively large size; depredation does not appear to be a major threat, at least not for adults (Squires and Reynolds 1997; USFWS 2007b). Great Horned Owls are likely the greatest predator for both adult and young (Rohner and Doyle 1992; Squires and Reynolds 1997), except for Haida Gwaii where these owls are absent. Depredation on Northern Goshawks in other regions of North America has been documented by eagle sp. (Squires and Ruggerio 1995), American Marten (Paragi and Wholecheese 1994), Black Bear (*Ursus americanus*; Mahon and Doyle 2003), and Wolverine (*Gulo gulo*; McGowan 1975). It is unlikely that depredation by any of these species has any serious impact on *laingi* subspecies populations.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Because of its rarity, relative secretiveness and the often remote nature of its habitat, Northern Goshawks are not well monitored by large-scale programs like the North American Breeding Bird Survey and the Christmas Bird Count. Specialized surveys are required.

Prior to 1994, only six Northern Goshawk *laingi* subspecies nests had been documented in British Columbia – five on Vancouver Island and one on the coastal mainland (Campbell *et al.* 1990). In 1994, systematic surveys consisting of call playback and standwatch surveys (RISC 2001) were initiated in east-central Vancouver Island (Ethier 1999). In 1995, the Province initiated systematic inventory surveys in central Vancouver Island (Quayle *et al.* 1995; McClaren 2003) and on central Haida Gwaii (Quayle *et al.* 1995; Chytyk and Dhanwant 1999). On Vancouver Island, the Province continued annual systematic surveys and research until 2002, gradually increasing survey coverage until much of the interior of the island was surveyed at least once (McClaren 2003). From 2002-2003 to the present, systematic surveys for proposed cutblocks and monitoring of known nest territories were continued mostly in central Vancouver Island (e.g., Lindsay *et al.* 2004; Manning *et al.* 2008a,b,c), but were generally less systematic and involved less effort than previously.

On Haida Gwaii, the Province continued to systematically inventory the archipelago for most years until the early 2000s. Between 2002 and the present, surveys and research on Haida Gwaii were conducted by a combination of the Province, forest licensees and Parks Canada. Little inventory work has been conducted on the coastal mainland. The Northern Goshawk *A. g. laingi* Recovery Team initiated some inventory work in selected areas of the coastal mainland in 2007 (NGRT 2008; Mitchell *et al.* 2008), while a few licensees conducted minor systematic surveys for proposed cutblocks and nest monitoring. The exception on the mainland coast is the former Kispiox Forest District on the northeastern portion of the Coast Mountain Range, where licensees conducted inventories and research between 1996 and 2007 (Mahon 2009b).

It is difficult to estimate the area covered and the precise amount of effort spent surveying and monitoring the *laingi* subspecies in British Columbia since 1994. Much of coastal British Columbia is rugged, remote and inaccessible; most of these areas have not been systematically surveyed. However, on Vancouver Island and Haida Gwaii, most accessible areas within the interior of the islands have been surveyed to some degree. On the mainland coast, other than the former Kispiox Forest District on the northeastern mainland coast of British Columbia, very few areas have been surveyed for the *laingi* subspecies.

In southeast Alaska, surveys and studies on the Northern Goshawk *laingi* subspecies were initiated in 1991 (Flatten 1997) and continued up to at least 2006 (Titus *et al.* 2006). Most survey effort in southeast Alaska has been concentrated in the Tongass National Forest.

Abundance

About half of the global population occurs in Canada, with the balance being in the United States, mostly in southeast Alaska (NGRT 2008). Population size is difficult to estimate, but estimates are based on the amount of foraging habitat within the landscape, factoring in nest territory occupancy rates of breeding pairs, plus the potential contributions of unmated adult birds to the overall population.

Not all nest areas are occupied annually by breeding pairs because adults, particularly females, may change territories across successive years (Iverson *et al.* 1996; McClaren 2003). Thus, the estimated number of breeding pairs in a given year is derived by multiplying the estimated number of potential territories by the annual nest territory occupancy rate of each respective region. As such, the Canadian breeding population of *A. gentilis laingi* is currently estimated to consist of 741-830 mature breeding individuals (Table 3). However, there are also unknown numbers of unmated adult goshawks that "float" in the population. These non-breeding adults could play an important role in buffering populations of *A. gentilis laingi* from decline (Iverson *et al.* 1996; Doyle and Smith 1994; Hunt 1998) and should be included in the population estimate. The proportion of the total Canadian population that is composed of such unmated mature individuals is unknown. In Sweden, Widen (1985) estimated that one-third of the adult goshawk population is non-breeding. Using this as a correction factor, the adjusted size of the Canadian population of the *laingi* subspecies falls between 1104 and 1237 mature individuals (Table 3). This may be an over-estimate, because annual fluctuations in population size are not taken into account. Harsh winter conditions and/or periods of low food abundance likely lead to population reduction in some years (see **Fluctuations and Trends).**

Table 3 is based on a 40% forage habitat supply model, which is the one favoured by the recovery team (MFLNRO and MOE 2013). Other population estimates can be derived using different forage supply thresholds. For example, a 60% forage supply value results in an estimate of only about 250-280 mature individuals, while a 20% forage supply value yields an estimate of about 1890-2080 individuals.

Table 3. Estimated size of the Northern Goshawk, *laingi* subspecies population in Canada, based on amount of current suitable habitat for each conservation region using a 40% forage supply threshold, scaled to reflect nest territory occupancy rates, and then adjusted to include unmated adults (adapted from Smith 2012; MFLNRO and MOE 2013; see text).

Measure	Haida Gwaii	North Coast	South Coast	Vancouver Island	Total
# of potential territories (range of five estimates)	37-44	223-234	184-209	238-277	682-764
Potential # of mature breeding individuals	74-88	446-468	368-418	476-554	1364-1528
Average estimated annual territory occupancy rate[1]	0.43	0.55	0.55	0.55	-

Measure	Haida Gwaii	North Coast	South Coast	Vancouver Island	Total
# of mature breeding Individuals (corrected for territory occupancy rates)	32-38	245-257	202-230	262-305	741-830
# of mature individuals including unmated adults[2]	48-57	365-383	301-343	390-454	1104-1237

[1] Estimates of occupancy rates are based on NGRT (2008) and E. McClaren pers. comm. 2013.
[2] Final value includes an estimate of 33% unmated adults as a proportion of the total population, but does not attempt to account for annual fluctuations in population size stemming from stochastic events that affect productivity and survivorship (see text).

Fluctuations and Trends

Annual fluctuations in nest territory occupancy are common in Northern Goshawk *laingi* subspecies populations (Titus *et al.* 1996; McClaren 2003; Manning *et al.* 2008c; Doyle 2012). For example, on Haida Gwaii, annual nest territory occupancy generally ranged from 13-80% (Doyle 2010, 2012), while on Vancouver Island it ranged from 23-100% (McClaren 2003; Manning *et al.* 2008c). It is presently unclear the extent to which changes in nest territory occupancy rates reflect annual fluctuations in actual population sizes, but nest territory occupancy is closely correlated to prey availability and weather patterns during the early breeding period (Bloxton 2002; Manning *et al.* 2004). Because harsh winter conditions and poor food supplies are known to impact Northern Goshawk populations through starvation and influence subsequent nest territory occupancy in other areas (Doyle and Smith 1994; Weins *et al.* 2006; Squires and Reynolds 1997), it is not unreasonable to assume that annual fluctuations in nest territory occupancy can lead to annual changes in populations.

Short-term trend data for Northern Goshawk *laingi* subspecies populations do not exist and historical (pre-industrial) population levels are unknown (USFWS 2007b; NGRT 2008). However, it is assumed that the *laingi* subspecies has declined from historical levels (Crocker-Bedford 1990; USFWS 2007b; Smith and Sutherland 2008), and is still in some form of decline (USFWS 2007b; NGRT 2008; NatureServe 2012). In some cases, significant long-term declines are assumed to have taken place. For example, on Haida Gwaii the population in the last 50 years is estimated to have declined by 63 – 67%, to possibly less than 20 territories (Doyle 2012). Assumed declines are based on the inference that the size of the *laingi* subspecies population is directly related to the amount of suitable mature and old-growth forest habitat present at a given time (USFWS 2007b; NGRT 2008).

Preliminary habitat trend data have been analyzed for Vancouver Island, Haida Gwaii and southeast Alaska using provincial and state forest cover databases (USFWS 2007b). The analyses showed that suitable habitat in 2005 had decreased from historical (pre-industrial) times by 43% on Vancouver Island, 25% on Haida Gwaii, and 10% for southeast Alaska. While it is unlikely that there is a one-to-one linear relationship between loss of suitable habitat and population decline, it is likely that the estimated 43% decline of habitat on Vancouver Island alone would have had a negative impact on local populations. Most of the suitable *laingi* subspecies habitat in southeast Vancouver Island has been removed by harvesting and settlement; localized population declines and extirpation in these areas are likely (Campbell *et al.* 1990; E. McClaren unpubl. data).

A population viability analysis for the *laingi* subspecies for coastal British Columbia found that the estimated decline from historical levels (740-1219 territories) to 2008 levels (144-1051 territories) did not appear to have substantively eroded future viability of the subspecies' population (Steventon 2012). In terms of meeting COSEWIC's extinction criteria, Steventon (2012) reported that 400 territories (800 mature individuals) would be required to meet 90% persistence over 100 years. While this is within the COSEWIC threshold of 10% probability of extinction, Steventon's (2012) analysis was based on a simplistic model that assumed that British Columbia contains a closed population and therefore ignored immigration from the U.S., which is known to occur. Moreover, his analysis calculated "quasi-extinction" risk, setting the threshold at <25 adult females. The actual risk of extirpation, therefore, would be lower had immigration and complete extirpation both been included in the analysis. Nevertheless, considering recent population and productivity trends on Haida Gwaii (which is effectively a closed population), Steventon (2012) raised doubts as to the future viability of that subpopulation and suggested that its prospects were poor.

On Haida Gwaii, preliminary nest territory modelling predicted that the number of viable territories (containing >40% mature and old forest) declined from up to 58 territories (totalling 10,000 ha in size) in 1800 to 10 in 2004, or an 82% reduction (Doyle 2005). Adjustments for observed occupancy rates suggested that only 4 to 13 territories on Haida Gwaii could be expected to support breeding in a given year, given the amount of suitable habitat available in 2004. A similar model predicted that viable territories on Haida Gwaii would continue to decline until about 2055, then begin to recover slightly as second-growth stands matured prior to harvest (Doyle and Holt 2005). Given these model assumptions, the probability of population persistence on Haida Gwaii was estimated at no more than 31% over the span of no more than 85 years (Doyle and Holt 2005).

In British Columbia, a habitat alteration-risk evaluation model was developed to estimate the relationship between the number of suitable nest territories supported on the land base and risk to *laingi* subspecies populations (Daust *et al.* 2010). This modelling exercise was based on expert opinion and was conducted only for the ecosystem-based management portion of the central coast mainland, so the results should be viewed cautiously. The model suggested that a low-risk threshold occurred for a population when 80% or more of the historically available suitable territories remained on the land base. Conversely, a high-risk threshold occurred for a population when 60% or less of the historically available suitable territories remained on the land base.

Rescue Effect

Throughout most of the *laingi* subspecies range there are few physical barriers between areas that might significantly limit potential dispersal and rescue effect from adjacent subpopulations. In the event that all Canadian Northern Goshawk *laingi* subspecies populations became extirpated, emigration from southeast Alaska could provide a source of rescue. However, rescue is considered unlikely based on the projected loss of habitat in Alaska (see **Habitat Trends**).

THREATS AND LIMITING FACTORS

Known and perceived threats were identified and ranked by the Northern Goshawk *Accipiter gentilis laingi* Recovery Team in October 2012 (D. Fraser, pers. comm. 2012) and are summarized below in order of importance. Based on calculations provided in Appendix A, the overall threat level impact on the *laingi* subspecies in Canada was determined to be Low.

Habitat Loss and Fragmentation

Forest harvesting and other commercial activities that remove trees on a large scale can impact Northern Goshawk *laingi* subspecies nest sites, prey abundance, and prey availability at both the stand and landscape levels by reducing and fragmenting nesting and foraging habitat (Cooper and Stevens 2000; USFWS 2007b; NGRT 2008). Localized harvesting can impact individual nest territory areas, while intensive harvesting that occurs across a region can impact local populations (Crocker-Bedford 1990; Iverson *et al.* 1996; Finn *et al.* 2002; McClaren 2003; Manning *et al.* 2008c). However, *A. g. laingi* territories are likely more resilient to the disturbance and habitat alterations caused by selective forest harvesting practices that have been specifically developed for the management of the subspecies (Finn *et al.* 2002; Manning *et al.* 2003; Mahon and Doyle 2005).

Large-scale forest harvesting impacts *laingi* populations by converting important nesting and foraging habitats (e.g., mature and old-growth forests) to young seral stages (e.g., clearcuts or dense young forest; USFWS 2007b; NGRT 2008). In many instances, harvesting may eliminate suitable nesting and foraging habitat areas, or fragment them to a degree that their suitability is reduced. Harvesting impacts nesting habitat by reducing the amount of potential nest trees, overhead canopy cover, and connectivity to habitats adjacent to nest areas. Clearcut forest harvesting can diminish the quantity and quality of foraging habitat by reducing the abundance, diversity and availability of prey species. Additionally, habitat fragmentation caused by large-scale harvesting increases the energetics required by breeding adults, due to the increased distances needed to travel to reach suitable foraging areas.

As remaining old-growth forests become limited due to past harvesting history, regenerating second-growth stands that may eventually provide suitable habitat (if allowed to mature) are increasingly being harvested. In productive coastal forests of Vancouver Island, harvest rotation periods typically span 50-80 years, which is the same period of time when these regenerating stands attain attributes that are suitable for nesting (McClaren 2003; Manning *et al.* 2006). In more northern areas, such as Haida Gwaii, these second-growth stands do not typically become suitable nesting and foraging habitat until they reach about 100 years of age (Doyle 2006b).

As the area of mature and old-growth forest becomes increasingly reduced across the landscape due to large-scale harvesting, maturing second-growth stands will become more important as potential nesting and foraging habitat for the *laingi* subspecies. The annual allowable cut in BC's coastal forest has dropped by 7.4 million m^3/yr since 1990. This represents a 30% decline in harvest over nearly three goshawk generations (J. Deal pers. comm. 2013). Nevertheless, the rate and extent at which suitable habitat is removed relative to its recruitment, and the levels of protection of currently suitable habitat, will determine the degree to which habitat loss and fragmentation continue to threaten the subspecies (NGRT 2008).

Other land-use activities such as those associated with rural, urban and agricultural development also cause habitat loss and fragmentation. While these occur at a much smaller scale than forest harvesting, their effects are permanent. Additionally, natural causes such as large windthrow events, fire, and forest insect and disease outbreaks may also reduce habitat quality for individual territories or regional populations.

Prey Diversity and Availability

Prey species diversity, abundance and availability may be a significant limiting factor for the subspecies, particularly for populations breeding on islands (USFWS 2007b; NGRT 2008). Many of the coastal islands, including Haida Gwaii and Vancouver Island, have less prey species diversity than on the coastal mainland (Dunn and Alderfer 2008; NGRT 2008). As a result, these island-breeding populations may be particularly susceptible to annual population fluctuations or long-term declines of key prey species. The annual population fluctuations of Red Squirrel due to conifer cone crop failure have been speculated to influence *laingi* subspecies productivity (Ethier 1999; Doyle 2005). On Haida Gwaii, preliminary investigations indicate that declining populations of a key prey species (Sooty Grouse) may also be influencing the *laingi* subspecies population (Doyle 2006a).

Genetic Isolation

The rugged and steep portions of the Coast Mountain Range act as a physical barrier between *A. g. laingi* and *A. g. atricapillus* populations (USFWS 1997; NGRT 2008). The potential for gene flow between the two subspecies is likely greatest at the southern end of the range of *A. g. laingi,* where Vancouver Island lies adjacent to the flatter topography of the lower mainland of British Columbia. Genetic studies indicate that gene flow occurs across much of the overlapping areas of the two subspecies ranges, particularly on Vancouver Island where goshawks have both *A. g. atricapillus* and *A. g. laingi* genetic characteristics (Talbot *et al.* 2005, 2011).

Genetic studies indicate that populations on Haida Gwaii have restricted contemporary gene flow with other Northern Goshawk *laingi* subspecies populations (Talbot *et al.* 2005, 2011; Sonsthagen *et al.* 2012). Immigration is important for countering genetic deterioration, but there are no data available that quantify the amount or degree of immigration from other *laingi* subspecies populations to Haida Gwaii. As a result, the small population that occurs on Haida Gwaii has the highest risk of genetic isolation.

Preliminary genetic work suggests that populations of the Northern Goshawk *laingi* subspecies may represent a metapopulation (Gust *et al.* 2003; Talbot *et al.* 2005, 2011; Sonsthagen *et al.* 2012). Metapopulations are groups of partially isolated subpopulations that are typically more vulnerable to loss of genetic diversity and overall extinction due to their smaller population sizes and isolation. Consequently, isolated or regional subpopulations of the Northern Goshawk *laingi* subspecies across its range may also be threatened by genetic isolation.

Introduced Species

Goshawk populations on Haida Gwaii may be impacted by various introduced species (Doyle 2006a; NGRT 2008). Sitka Black-tailed Deer (*Odocoileus hemionus sitkensis*) indirectly impact songbird prey populations by over-browsing much of the understory vegetation on Haida Gwaii (Englestoft and Bland 2002). Songbird abundance was 55-70% lower on Haida Gwaii islands with a more than a 50-year history of deer browsing compared to islands without deer (Allombert *et al.* 2005). Sooty Grouse populations may also be impacted by high levels of deer browsing (Doyle 2004, 2006).

The Raccoon was introduced to Haida Gwaii and is a potential predator of prey sought by the *laingi* subspecies, and likely also preys on goshawk nestlings (Chytyk and Dhanwant 1996; Laskeek Bay Conservation Society 1996 cited in NGRT 2008). Other predators of prey species such as Black Rat (*Rattus rattus*), Norway Rat (*Rattus norvegicus*) and Red Squirrel have also been introduced to Haida Gwaii and may indirectly impact *laingi* populations by reducing bird prey (Martin *et al.* 2001). While the Red Squirrel has spread throughout Haida Gwaii and has itself become an important prey species for the *laingi* subspecies on the archipelago (Roberts 1997; Doyle 2006b), it is unclear how it may be influencing or impacting populations of the *laingi* subspecies (NGRT 2008).

It is unlikely that introduced species within other areas of the Northern Goshawk *laingi* subspecies range are threats (NGRT 2008).

Depredation and Competition

Young seral stages and fragmented habitats created by forest harvesting may favour potential predators and competitors such as Red-tailed Hawk, Barred Owl and Great Horned Owl that tend to prefer edge and more open habitats (Squires and Reynolds 1997; USFWS 2007b; NGRT 2008). The *laingi* subspecies may be outcompeted by these species in these habitat types because it tends to be more adapted to more intact and closed-canopied habitats (USFWS 2007b). At times, Red-tailed Hawks and large owl species may re-use old goshawk nests and thus displace Northern Goshawks from their nest area and impact nesting effort (Squires and Reynolds 1997). It is unclear how large of a threat that potential depredation and competition is on the *laingi* subspecies, but this threat likely increases as intact forest habitats become cleared and fragmented (USFWS 2007b; NGRT 2008).

Climate Change

The potential threats caused by climate change for the *laingi* subspecies are currently unknown and difficult to predict (USFWS 2007b; NGRT 2008). Climate change may lead to altered microclimate conditions and changes in tree species composition in coastal forests (Hamann *et al.* 2006 cited in NGRT 2008). This in turn may alter prey abundance and availability and increase the likelihood of forest fires, disease, and insect pest outbreaks (Province of BC 2008). Many climate change models predict a higher rate of climate extremes and increased environmental stochastic events, neither of which would likely benefit *laingi* subspecies populations.

Some studies have speculated that changes in climatic conditions may indirectly contribute to greater nestling mortality (Doyle 2008b). In the former Kispiox Forest District on the northeastern coastal mainland, changes to precipitation patterns and earlier warmer temperatures altered the timing of blackfly hatch dates, thus increasing their abundance at critical times during the goshawk's breeding cycle (Doyle 2008b). Blackflies feed on nestlings, causing significant blood loss and stress and, at times, leading to death (F. Doyle, pers. comm. 2007). Several studies have suggested that the higher precipitation levels predicted from climate change negatively impact nest territory occupancy, nest productivity and prey abundance (Bloxton 2002; Manning *et al.* 2004; Doyle 2009).

Warmer temperatures predicted by most climate change models are expected to affect forest species composition and distribution as warmer-adapted tree species such as Douglas-fir expand northward and cool-adapted Western Hemlock invade alpine areas (Hamann *et al.* 2006; USFWS 2007b). These changes could benefit *laingi* subspecies populations.

Human Disturbance

There are no empirical data that quantify the amount or degree of human disturbance that may impact the Northern Goshawk *laingi* subspecies. The degree of impact of human disturbance near nest sites likely depends on the timing, intensity and proximity of the disturbance (NGRT 2008). Some individuals may be more sensitive to disturbance than others, and may be prone to nest abandonment if disturbed. Birds will build their nests within 15 m of deactivated forestry roads, 60 m of regularly used forestry haul roads, and within 200 m of regularly driven highways (Manning *et al.* 2005). In addition, Mahon *et al.* (2008) analyzed distance of nests to hard edges on Vancouver Island and found that >80% were >200 m away, which suggests some edge avoidance.

Disease

There is no evidence that the *laingi* subspecies has experienced any significant mortality from disease that would considerably impact their populations (USFWS 2007b). However, captive birds frequently die from disease (Squires and Reynolds 1997). Stress from other factors such as shortage of prey can make Northern Goshawks more vulnerable to disease outbreaks in populations elsewhere (e.g., Redig *et al.* 1980 cited in USFWS 2007b), and may act similarly in the *laingi* subspecies. West Nile virus is considered to be the most widely distributed vector-borne disease in North America and it has recently been detected in British Columbia (BC CDC 2012a). The virus appears to be fatal in Northern Goshawks (Wunschmann *et al.* 2005). However, until cases of specific infections are reported, the threat of the virus to *laingi* subspecies is currently unknown.

Human Persecution

Human persecution has likely never been a significant threat to Northern Goshawk *laingi* subspecies populations (NGRT 2008). Historically, goshawks were sometimes killed as pests by farmers protecting poultry stocks – a practice that persisted until recently on Haida Gwaii (G. Morigeau, pers. comm. 1995), and today still likely continues as isolated incidents across their range. Northern Goshawks have long been valued by falconers for their aggressive nature and willingness to pursue prey (Squires and Reynolds 1997). However, it is unlikely that falconry collection has ever been of significance for *laingi* subspecies populations. Both Vancouver Island and Haida Gwaii have been closed to falconry harvest since 1994 (M. Chutter, pers. comm. 2012). Human persecution toward the *laingi* subspecies is considered to be low and not a major threat (NGRT 2008).

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

<u>International</u>

The Convention on International Trade in Endangered Species (CITES) lists the Northern Goshawk *laingi* subspecies in Appendix II, a species that is not necessarily now threatened with extinction but may become so unless trade is closely controlled (CITES 2012). Due to this designation, specimens to be exported from Canada must be accompanied by a Canadian CITES export permit (Environment Canada 2012). No other protection for the subspecies is afforded through the CITES designation.

Canada

The subspecies is listed as a Schedule 1 Threatened species under Canada's *Species at Risk Act* (Government of Canada 2012). It must not be killed, harmed, harassed, captured or taken. Possession of and trade in the species is forbidden. Destruction of the species' residences (defined as nests) is prohibited and residences are protected on federal lands only. Under the *Species at Risk Act*, a process has been established for delineating potential critical habitat around known nest sites; draft critical habitat boundaries were completed in 2012 and are currently in review (R. Vennesland, pers. comm. 2011).

British Columbia

Several provincial acts provide some degree of direct and indirect legal protection for the Northern Goshawk *laingi* subspecies. The principal legislations and mechanisms for legal protection are outlined below.

The *Wildlife Act* protects the subspecies by making it an offence to injure, molest, or destroy a bird, its egg, or occupied nest (Province of BC 1996c).

The *Forest and Range Practices Act* (FRPA) contains a number of provisions that contribute to managing the subspecies (Province of BC 2002). These include provisions that require forest stewardship plans to specify intended results or strategies in relation to objectives set for the *laingi* subspecies by government. In 2004, notices were established for five forest districts along British Columbia's coast that designated the amount of area, the distribution, and habitat attributes of those areas that were required for the management of the subspecies; such managed areas totalled 4133 ha in size (BC MOE 2012). In addition, the Identified Wildlife Management Strategy (IWMS) provides direction, procedures and guidelines for managing Species at Risk, including the *laingi* subspecies (BC MWLAP 2004). Under the IWMS, Wildlife Habitat Areas (WHAs) may be established and managed around nest territories (McClaren 2004). To date, 28 such WHAs ranging in size from 32 – 2592 ha in size have been established, totalling an area of 14,764 ha (P. Hubregtse, pers. comm. 2012). Provisions under FRPA for the conservation and management of Species at Risk are not to unduly reduce the supply of timber from British Columbia's forests. As a result, the impacts from these provisions across all species at risk have been limited to 1% of the short-term timber supply of the mature timber harvesting land base calculated by forest district (BC MWLAP 2004). Additionally, under FRPA, ungulate winter ranges may be established (Province of BC 2002), many of which are characterized by mature forests that are suitable Northern Goshawk *laingi* subspecies habitat.

The *Land Act* allows for the establishment of Old Growth Management Areas (OGMAs), which are protected areas of old-growth habitat that maintain biodiversity values (Province of BC 1996a). Although OGMAs are not necessarily established specifically for protecting Northern Goshawk *laingi* subspecies nest territories, provincial policy is to overlap OGMAs with suitable Species at Risk habitats where possible.

The *Park Act* provides for the protection of the Northern Goshawk *laingi* subspecies in provincial parks by not allowing the birds to be granted, sold, removed, destroyed, damaged, disturbed or exploited except as authorized by a valid park use permit (Province of BC 1996b).

Land use plans can also provide legislative protection by establishing protected areas or management direction for the conservation of the subspecies. Land use plans can set targets for biodiversity and species management in excess of current government policy on timber impacts. For example, many of the known *laingi* subspecies nest territories on Haida Gwaii have had their nest sites protected by establishing spatial reserves under the Haida Gwaii Land Use Order Objective (Province of BC 2007).

A provincial Recovery Strategy was completed for the *laingi* subspecies (NGRT 2008). Recent recovery actions by the recovery team include the development of nesting and foraging habitat suitability models for the four Canadian conservation regions (Mahon *et al.* 2008; Smith and Sutherland 2008; Mahon 2009a, 2011; Doyle *et al.* 2010). Revised habitat suitability maps were completed in 2012 for the entire Canadian *laingi* subspecies range (T. Mahon, pers. comm. 2012). A revised model has also been developed to predict how many pairs could potentially be supported in each conservation region (MFLNRO and MOE 2013.

United States

In Alaska, the U.S. Forest Service designated the Northern Goshawk *laingi* subspecies a Sensitive Species in 1994 (USDAFS 1997). The Alaska Department of Fish and Game (ADFG) designated the Northern Goshawk *laingi* subspecies a Species of Special Concern in 1998 (Iverson *et al.* 1996; ADFG 1998), because of threats to its nesting and foraging habitat. In 2011, the ADFG no longer maintained a Species of Special Concern list for Alaska, because the list had not been reviewed and revised since 1998 (ADFG 2012). Subsequently, the ADFG now manages former Species of Special Concern for Alaska in its Wildlife Action Plan as a Featured Species; the plan details measurable conservation goals and strategies for the subspecies (ADFG 2006).

In Washington, the Washington Department of Fish and Wildlife only recognizes *A. g. atricapillus* as occurring in Washington and has designated it a State Candidate, a species that the Department will review for possible future listing (Desimone and Hays 2004; WDFW 2012).

Non-Legal Status and Ranks

The Northern Goshawk *laingi* subspecies is listed as globally imperiled (G5T2), nationally imperiled in both Canada and United States (N2), and imperiled in both British Columbia and Alaska (S2; NatureServe 2012). There is no Canadian General Status rank assigned to the *laingi* subspecies (CESCC 2011). In British Columbia, the subspecies is provincially Red-listed (a candidate for Endangered or Threatened status in British Columbia) and a Priority 1 species (the highest conservation priority) under the provincial Conservation Framework (BC CDC 2012b).

Habitat Protection and Ownership

A recent estimate of the amount of potential *laingi* subspecies habitat that has some degree of protection in Canada is about 35% of the total potential habitat, whether for foraging or nesting (Table 4). Protected habitat includes National Parks, Provincial Parks, Ecological Reserves, Protected Areas, Regional Parks, Conservancies, Forest Recreation Sites, Heritage Sites, Class 1 Grizzly Bear habitat, Wildlife Habitat Areas, Wildlands, Biodiversity, Mining and Tourism Areas, Old Growth Management Areas (legal and non-legal), Forest Reserves, Recreation Areas, Ungulate Winter Ranges, Strategic Landscape Reserve Design Reserves, Land Use Objective Order Schedule 9, and Wildlife Management Areas.

Table 4. Amount of potential Northern Goshawk *laingi* subspecies habitat with some degree of protection in Canada[1].

Habitat type	Total area (ha)	Protected area (ha)	Protected %
Foraging habitat	4,732,679	1,644,533	35%
Nesting habitat	1,908,199	694,930	36%

[1] Estimates are potential amounts of suitable goshawk habitat that are classified as being of either "moderate"or "high" suitability for foraging and nesting. Source: MFLNRO (2012).

In southeast Alaska, the primary way that the subspecies' habitat is protected is through the conservation strategy of the Tongass Land and Resource Management Plan (USDAFS 1997). This Plan is legally binding on the Forest Service (USFWS 2007). In total, requirements within the Plan, as well as protected areas, retention areas and other strategies, protect an estimated 1,418,314 ha of potential *laingi* subspecies habitat, or 55% of the 2,587,993 ha of productive forest in southeast Alaska (USFWS 2007).

There are two known Northern Goshawk *laingi* subspecies breeding areas currently protected on federal lands in Canada. One is near Windy Bay and the other is near Sandy Creek, both in Gwaii Haanas National Park Reserve on Haida Gwaii. The two breeding areas are about 6 km apart and have not been simultaneously occupied during the same year (F. Doyle, pers. comm. 2012). It is likely that there are additional nest territories in other areas of Gwaii Haanas National Park Reserve and Pacific Rim National Park Reserve on Vancouver Island, as there is suitable habitat in both these areas. On Vancouver Island, there are 26 nesting areas protected in WHAs, 4 in provincial parks and 1 in an ecological reserve (E. McClaren, unpubl. data 2011). On Haida Gwaii, there are 11 nesting areas protected under the Haida Gwaii Land Use Objectives Order (HGLUOO), 2 protected in WHAs, 2 in Conservancies, 2 in Gwaii Haanas National Park Reserve, and 1 with interim protection measures under the HGLUOO (A. Cober, pers. comm. 2012). No WHAs have been approved for either the north or south coasts, though some have been proposed for the north coast (R. Vennesland pers. comm. 2013).

In British Columbia, two conservation initiatives are currently being developed to specifically protect additional nesting and foraging habitat: critical habitat designation (R. Vennesland, pers. comm. 2012) and the implementation of Ecosystem-Based Management (EBM) for coastal British Columbia (Horn *et al.* 2009). The draft process for establishing critical habitat for the persistence of the *laingi* subspecies as stipulated under the *Species at Risk Act* has been initiated by Parks Canada (R. Vennesland, pers. comm. 2012). Critical habitat polygons are being developed in all four conservation regions.

Through the implementation of the EBM, suitable nesting and foraging habitat will be co-located with representative old forest ecosystems (Horn *et al.* 2009). The EBM will be applied to an area of about 6 million ha on the central and north coasts of British Columbia (often referred to as the 'Great Bear Rainforest'). Potentially 800,000 ha or more of mature and old forest may be captured through the EBM planning and strategic reserve design process.

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Previous status reports for the Northern Goshawk *laingi* subspecies were completed by P. Duncan and D.A. Kirk in 1995 and J.M. Cooper and P.A. Chytyk in 2000.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Paul Chytyk has worked as a wildlife consultant for over 20 years in British Columbia, Alberta and Saskatchewan. He owns and operates YUNI Environmental Consulting based out of Victoria, BC and has annually coordinated wildlife inventories and environmental impact assessments across British Columbia for the past 15 years. Paul has participated in the development and implementation of many of B.C. Ministry of Environment's principal rare and endangered species policies, strategies and legislative efforts. Paul has been involved with the inventory, monitoring, and development of habitat models for the Northern Goshawk *laingi* subspecies in British Columbia since 1995. He has annually coordinated survey and inventory projects for the subspecies between 1995 and 2008 throughout coastal British Columbia, including: Haida Gwaii (1995-2008) and northern Vancouver Island (2002-2008). He has developed and ground-truthed habitat suitability models for the subspecies for Haida Gwaii and northern Vancouver Island, and for the *A. g. atricapillus* subspecies for northeastern Alberta, and south-central and northeastern British Columbia. Paul co-authored the 2000 COSEWIC updated status report for the Northern Goshawk *laingi* subspecies.

Todd Manning is a Registered Professional Biologist and a Registered Professional Forester, and has been a forestry and wildlife consultant on numerous projects in British Columbia and Alberta since the early 1980s. Todd is noted as an expert in forestry-wildlife interactions, particularly wildlife habitat suitability assessments and the development of best management practices for species at risk. He is also an acknowledged expert in the ecology and management of wildlife trees and wildlife tree dependent species, and related innovative ecosystem restoration techniques. Todd has worked specifically with the Northern Goshawk *laingi* subspecies on Vancouver Island over the past 10 years, conducting a variety of associated inventory, habitat assessment and modelling, and adaptive management/conservation related projects. Over the past few years, Todd has been extensively involved with the implementation of Ecosystem-Based Management on the coast of British Columbia, primarily involving policy development and land use and conservation planning for focal species (including Northern Goshawk *laingi* subspecies). Todd has been a past-member of the Northern Goshawk *laingi* subspecies Recovery Team.

Paul Chytyk and Todd Manning have collaborated on various inventory projects, habitat models, and species reports for the Northern Goshawk *laingi* subspecies since 1998.

Appendix A. Threats Assessment Worksheet for the Northern Goshawk, *laingi* subspecies in Canada.

Species or Ecosystem Scientific Name	Northern Goshawk, laingii ssp
Date (Ctrl + ";" for today's date):	12/10/2012

Overall Threat Impact Calculation Help:

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	0	0
D	Low	3	3
	Calculated Overall Threat Impact:	Low	Low

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing
1	Residential & commercial development		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Moderate - Slight (1-30%)	High (Continuing)
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
2.1	Annual & perennial non-timber crops		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
2.2	Wood & pulp plantations		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)
3	Energy production & mining		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
3.3	Renewable energy		Negligible	Negligible (<1%)	Unknown	High (Continuing)
4	Transportation & service corridors	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)
4.1	Roads & railroads	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)
4.2	Utility & service lines		Negligible	Negligible (<1%)	Unknown	High (Continuing)
4.4	Flight paths		Negligible	Negligible (<1%)	Unknown	High (Continuing)
5	Biological resource use	D	Low	Small (1-10%)	Serious - Moderate (11-70%)	High (Continuing)
5.1	Hunting & collecting terrestrial animals		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
5.2	Gathering terrestrial plants		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)
5.3	Logging & wood harvesting	D	Low	Small (1-10%)	Serious - Moderate (11-70%)	High (Continuing)
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)
6.1	Recreational activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)
7	Natural system modifications	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)
7.1	Fire & fire suppression		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
7.3	Other ecosystem modifications	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing
8	Invasive & other problematic species & genes		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)
8.1	Invasive non-native/alien species		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)
9	Pollution					
10	Geological events		Negligible	Negligible (<1%)	Extreme (71-100%)	Moderate (Possibly in the short term, < 10 yrs)
10.2	Earthquakes/tsunamis		Negligible	Negligible (<1%)	Extreme (71-100%)	Moderate (Possibly in the short term, < 10 yrs)
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)
11	Climate change & severe weather		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)
11.1	Habitat shifting & alteration		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)
11.3	Temperature extremes		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)
11.4	Storms & flooding		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)